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RESEARCH ARTICLE

Comparative Proximate Composition of Selected Cultivars of Bitter Gourd (*Momordica charantia*) Fruit through its Flour Formation

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ABSTRACT

Background: The proximate analysis is crucial to ascertain more desirable cultivars with abundant chemical constituents to be used against numerous diseases.
Objective: Purpose of this study was to determine the proximate composition of six cultivars of bitter gourd (*Momordica charantia* L.) viz., Black King, GHBG-1, KHBG-1, FSD Long, BG 20, and Noor for use as flour.
Methodology: The whole fruit (with peel and seeds), and skin, flesh, seeds were dried separately and grind to obtain fine flour. All the determinations were made in triplicate and data of all the cultivars were compared for various parameters.
Results: The high moisture contents were observed in flesh part of cultivar BG 20 (9.07±0.55%) while the least moisture contents were found in seeds of GHBG-1 (5.20±0.30%). The flesh was rich in ash and protein contents. The least protein contents were observed in the seeds of KHBG-1 with value of 9.06%. Different cultivars of bitter gourd and fruit showed significant differences regarding crude fat contents. The maximum crude fiber contents were observed in seeds of different cultivars *i.e.*, 21.42 (BG 20), 19.07 (Black King), 18.89 (Noor), 18.7 (GHBG-1), 17.11(KHBG-1), and 16. 51 (FSD Long). The fruit skin had the highest amount of nitrogen free extract [72.34 (BG 20), 67.6 (Black King), 61.09 (FSD Long), 69.76 (KHBG-1), 58.0 (GHBG-1) and 57.28 (Noor)] followed by flesh part (70.29, 65.27, 56.62, 68.25, 56.82 and 56.13%, respectively).
Conclusion: proximate composition of flour of bitter gourd fruit showed that different cultivars and fruit parts showed remarkable differences regarding different nutritional components. Black King cultivar was more promising followed by FSD Long and BG 20. It is suggested that flour of these cultivars should be further analyzed for phytonutrient and biochemical evaluation.

INTRODUCTION

The regular consumption of vegetables is essential to maintain human health as these have bevy of chemical compounds that have nutritional as well as medicinal properties. Many disorders are related to inadequate consumption of vegetables. The intake of a specific food may assuage several types of ill effects due to modulatory effects of chemicals moieties present in them. Dietary interventions may help reduce the chances of onset of diseases and reduce the severity of symptoms associated with diseases. The bitter gourd (*Momordica charantia* L.), a member of the family Cucurbitaceae. It is a thin vine, produces fruit in summer season which is bitter in taste (Yan *et al.* 2019) and reported to have a role in mitigation of several lifestyle-related disorders.

In recent years, many studies highlighted the potential of bitter gourd fruit in reducing cholesterol (Bano *et al.* 2011; Tayyab *et al*. 2012; Tayyab and Lal 2013), visceral fat mass (Chen *et al*. 2012), blood glucose level (Paul and Raychaudhuri 2010; Fuangchana *et al*. 2011; Wehash *et al.* 2012; Tayyab and Lal 2013), and cellular proliferations in cancer (Ray *et al*. 2010; Manoharan *et al*. 2014), as well as provide positive impact against HIV and neurodegenerative diseases (Fang and Ng 2011). The diverse chemicals present in this plant impart anti-tumor, antioxidative, anti-hyperlipidemic, anti-diabetic, anti-mutagenic, anti-inflammatory, anti-ulcerogenic, and immune-modulatory activities (Islam *et al.* 2011; Gill *et al*. 2012; Lu *et al*. 2012; Mohammady *et al.* 2012; Joseph and Jini 2013; Chao *et al*. 2014; Majumda and Debnath 2014). These wide ranges of benefits are due to the presence of diverse chemicals in different parts of its fruit.

To explore a more desirable variety with suitable chemical composition, proximate analysis is crucial. Such a chemical analysis provides a basis to determine the presence of antioxidants, nutrients, phytochemicals, and resultant physiological functions. Moreover, nutritional status and overall composition are important criteria to determine beneficial aspects of any ingredient used as food. Furthermore, chemical composition is critically important for the development of designer foods. As bitter gourd is a natural source of vital chemicals, it can be used as a functional food to benefit health (Lee *et al.* 2013). The peel and seeds of this fruit are considered inedible, although its skin is a rich source of minerals, lipids, proteins, and fibres (Andrade *et al.* 2023). The seeds are also a reservoir of many macro- and micronutrients such as proteins, carbohydrates, minerals, bioactive compounds, and vitamins. The chemicals present in the skin and seeds of bitter gourd might be a good source of bioactive components to boost health and provide protection against wide ranging human malignancies (Singla *et al.* 2023).

Some previous studies explored the chemical composition of leaf, fruit, and pericarp of bitter gourd in different geological regions of the world (Bakare *et al.* 2010; Horax *et al.* 2010; Saeed *et al.* 2018). As different cultivars are genetically diverse, the present research is planned to assess the comparative proximate composition of fruit and its parts in different lines grown in similar climatic, geographical and agronomical conditions.

MATERIALS AND METHODS

Procurement of bitter gourd materials

In the present study, proximate composition of six cultivars of bitter gourd (*Momordica charantia* L.) viz., Black King, GHBG-1, KHBG-1, FSD Long, BG 20, and Noor was made (Fig. 1). The fruits of selected cultivars were procured from Ayub Agricultural Research Institute, Faisalabad-Pakistan. The selection of cultivar was based on yield and other quality attributes (freshness, not fully mature etc.).

Handling of materials

The fruits of selected cultivars were washed with water to remove soil particles, adhered dust, or other undesirable objects. The fruits were dried at room temperature for a few hours. The skin of the fruit was peeled. The fruits were cut open to remove the seeds. The remaining fruit was cut to small sized pieces. After cutting whole fruit (with peel and seeds), small slices were obtained (Fig. 2). The whole fruit and its parts (skin, flesh, seeds) for each cultivar were collected separately in plastic jars. These fruit parts and whole fruit were dried in sunlight till dried completely except retaining small proportion used to determine moisture contents. The dried fruit parts and whole fruits of different cultivars were ground with the help of a small laboratory grinder. The powder obtained after grinding was sieved to obtain fine flour. The coarse powder was grinded again to refine further. The fine flour was stored separately in labelled air-tight polythene bags to be used for further analysis.

Proximate analysis

The fruit of different cultivars and parts were analyzed for proximate composition using the methods given below.

Moisture content: To determine moisture contents, 3g of sample was dried at 105±5ºC using hot air oven following Method No. 44-01 (AACC 2000). The drying continued until the constant weight of the sample was obtained. Following formula was used to calculate moisture contents in fruit of different cultivars and parts:

$$\text{Moisture contents \%} = \frac{W1 - W2}{W1} \times 100$$

Where W1 is the weight of fresh sample and W2 is weight of dry sample.

Ash content: The AACC Method No. 08-01was used to determine the ash contents. The sample was incinerated directly in crucible (AACC 2000). Then the crucible was heated on oxidizing flame. The fumes gradually disappeared while heating continuously. Then, muffle furnace (MF-1/02, Pakistan) was used to ignite at 550 °C temperature till gray white residues appeared. Following formula was applied to calculate ash contents:

$$\text{Ash content (\%)} = \frac{W1}{W0} \times 100$$

Where W1 is weight of dry sample (g) and W0 is the weight total sample (g)

Crude protein: The nitrogen contents were estimated using Kjeltech Equipment (Model number: 808, Behr Dusseldort) following the procedure described in Method No. 46-13 (AACC 2000). The digestion mixture (K_2SO_4:$FeSO_4$:$CuSO_4$ in the ratio of 10:5:85) and concentrated H_2SO_4 were used to digest the samples repeatedly after every 3 h until transparent or light green color appeared. The material after digestion was obtained and diluted with 250 mL of water. In distillation apparatus, 10 mL of 40% NaOH solution was taken to distill 10 mL of diluted sample. Liberation of ammonia started, which was estimated using methyl red indicator in 4% boric acid solution. Lastly, the titration of this distillate using 0.1 N H_2SO_4 was performed till golden brown color appeared. Following formula was used to

Fig. 1: Fruits of different cultivars of bitter gourd used in this study

Fig. 2: Fruit and its components

determine presence of crude protein (%) based on the N content of the sample:

$$N\,(\%) = \frac{V1 \times V2 \times 0.0014}{W0 \times V3} \times 100$$

$$\text{Crude protein}\,(\%) = 6.25 \times N\,(\%)$$

Where W0=weight of sample, V1=Volume of 0.1 normal H_2SO_4 (mL), V2= Volume of dilution (g), V3= Volume of sample before dilution (mL)

Crude fat: To analyze crude fat contents in the sample (Method No. 30-10), 3g of flour was taken in solvent (n-hexane) using Soxhlet Apparatus (AACC 2000):

$$\text{Crude fat \%} = \frac{W1}{W0} \times 100$$

Where W1= weight of fat (g) and W0 is the weight of plant sample (g).

Crude fiber: To estimate crude fiber in the sample, simultaneous digestion with H_2SO_4 (1.25%) and NaOH (1.25%) solutions was carried out. Labconco Fibertech (USA) was used for determination of crude fiber contents in the sample. The ignition of sample at 550ºC in muffle furnace had resulted in formation of white residues. Method No. 32-10 was used to determine percentage of fiber in sample (AACC 2000). The following expression was used to calculate the crude fiber content:

$$\text{Crude fiber \%} = \frac{W1}{W0} \times 100$$

Where W1= weight loss on ignition (g), W0 is the weight of plant sample (g).

Nitrogen free extracts (NFE): The NFE in sample is determined by using the sum of all percentages of nutrients and subtracting from 100 (McClement *et al.* 2021), as given below:

NFE (%) = 100 – (% ash + % crude protein + % crude fat + % crude fiber)

Data analysis

Data were analyzed to find differences among the cultivars and their respective parts using Statistix v.8.1. The graphical presentation of the data was made using MS Excel 365.

Chemicals

The chemicals used to analyze proximate composition were of analytical grade and purchased from Sigma-Aldrich, Japan, Cayman, Europe and Merck.

RESULTS

Different chemical attributes of selected bitter gourd cultivars and fruit parts showed significant differences in different parameters (Fig. 3a). The flesh part has higher moisture contents in all cultivars *i.e.*, 9.07 (BG 20), 8.1 (KHBG-1), 7.63 (FSD Long), 7.63 (Noor), 7.6 (Black King), and 7.43 (GHBG-1). The seeds were found to possess low moisture contents i.e., 6.23 (BG 20), 5.93 (Black King), 5.63 (FSD Long), 6.17 (KHBG-1), 5.2 (GHBG-1), and 5.73 (Noor). The moisture contents in skin of different cultivars were 7.97 (BG 20), 6.9 (Black King), 6.4 (FSD Long), 6.77 (KHBG-1), 6.6 (GHBG-1) and 6.87 (Noor). The high moisture contents were also observed in whole fruit with values of 8.00 (BG 20), 7.03 (Black King), 7.37 (FSD Long), 7.1 (KHBG-1), 6.6 (GHBG-1) and 7.27 (Noor).

It was obvious from results that flesh part is rich in ash contents (Fig. 3b) i.e., 2.86, 4.39, 3.6, 3.71, 2.37, and 2.06% followed by skin (2.72, 3.18, 3.1, 2.81, 2.09 and 2.34%), whole fruit (2.39, 3.33, 3.23, 2.98, 2.13 and 1.88% and seeds (1.31, 1.83, 1.87, 1.41, 1.19 and 1.11%) for BG 20, Black King, FSD Long, KHBG-1, GHBG-1 and Noor respectively.

Results regarding crude protein contents in different cultivars of bitter gourd (Fig. 3c) indicated that flesh part of cultivar Noor, FSD Long, and GHBG-1 possess high protein contents i.e., 33.14, 30.53 and 30.07, respectively. The protein contents in flesh part of other cultivars were 16.52, 17.87 and 18.29 for BG 20, Black King and KHBG-1 respectively. The least protein contents were observed in the seeds of KHBG-1 with value of 9.06 % while seeds of cultivar FSD Long had the highest crude protein content (14.47%).

Different cultivars of bitter gourd and fruit parts showed significant differences regarding crude fat contents (Fig. 3d). The results indicated that seeds of different cultivars are rich in crude fat contents (%) i.e., 14.19 (BG 20), 14.28 (Black King), 11.48 (FSD Long), 13.5 (KHBG-1), 9.23 (GHBG-1), and 10.15 (Noor). The least amount of fat was found in the skin part of cultivar Noor (6.42%).

As presented in Fig. 3e, the maximum crude fiber contents were observed in seeds of different cultivars *i.e.*, 21.42 (BG 20), 19.07 (Black King), 18.89 (Noor), 18.7 (GHBG-1), 17.11(KHBG-1), and 16. 51 (FSD Long). The comparative low amount of fiber contents were observed in skin [(2.24 (BG 20), 3.81 (Black King), 1.21 (FSD Long), 2.34 (KHBG-1), 1.55 (GHBG-1), and 1.86 (Noor)] and flesh [(3.83 (BG 20), 4.02 (Black King), 1.84 (FSD Long), 2.28 (KHBG-1), 2.33 (GHBG-1), and 2.15 (Noor)].

Fig. 3f depicted that amounts of NFE were remarkably different in different parts and cultivars. The skin part of fruit displayed the highest amount of NFE [(72.34 (BG 20), 67.6 (Black King), 61.09 (FSD Long), 69.76 (KHBG-1), 58.0 (GHBG-1), and 57.28 (Noor)] followed by flesh part (70.29 (BG 20), 65.27 (Black King), 56.62 (FSD Long), 68.25 (KHBG-1), 56.82 (GHBG-1), and 56.13% (Noor)). The NFE (%) in whole fruit of different cultivars were found to be 68.15% (BG 20), 62.9% (Black King), 54.28% (FSD Long), 64.23% (KHBG-1), 57.39% (GHBG-1) and 57.53% (Noor).

DISCUSSION

The results of the current study indicated low values of moisture contents. These low values are important to protect the flour from microbial contamination or spoilage and to enhance the storage period. Hussain *et al.* (2024) also reported that peel, flesh and seeds of bitter gourd possess lesser amount of moisture contents with values of 6.10, 7.10 and 4.88, respectively. In a similar way, Gayathri (2014) found low moisture contents (6.14%) in bitter gourd fruit. In another study, Aslam *et al*. (2013) also found low moisture contents (4.71%) in bitter gourd fruit. Similarly, Saeed *et al*. (2010) analyzed bitter gourd flakes, peel, and seed for moisture contents and found moisture contents of 4.72, 4.15

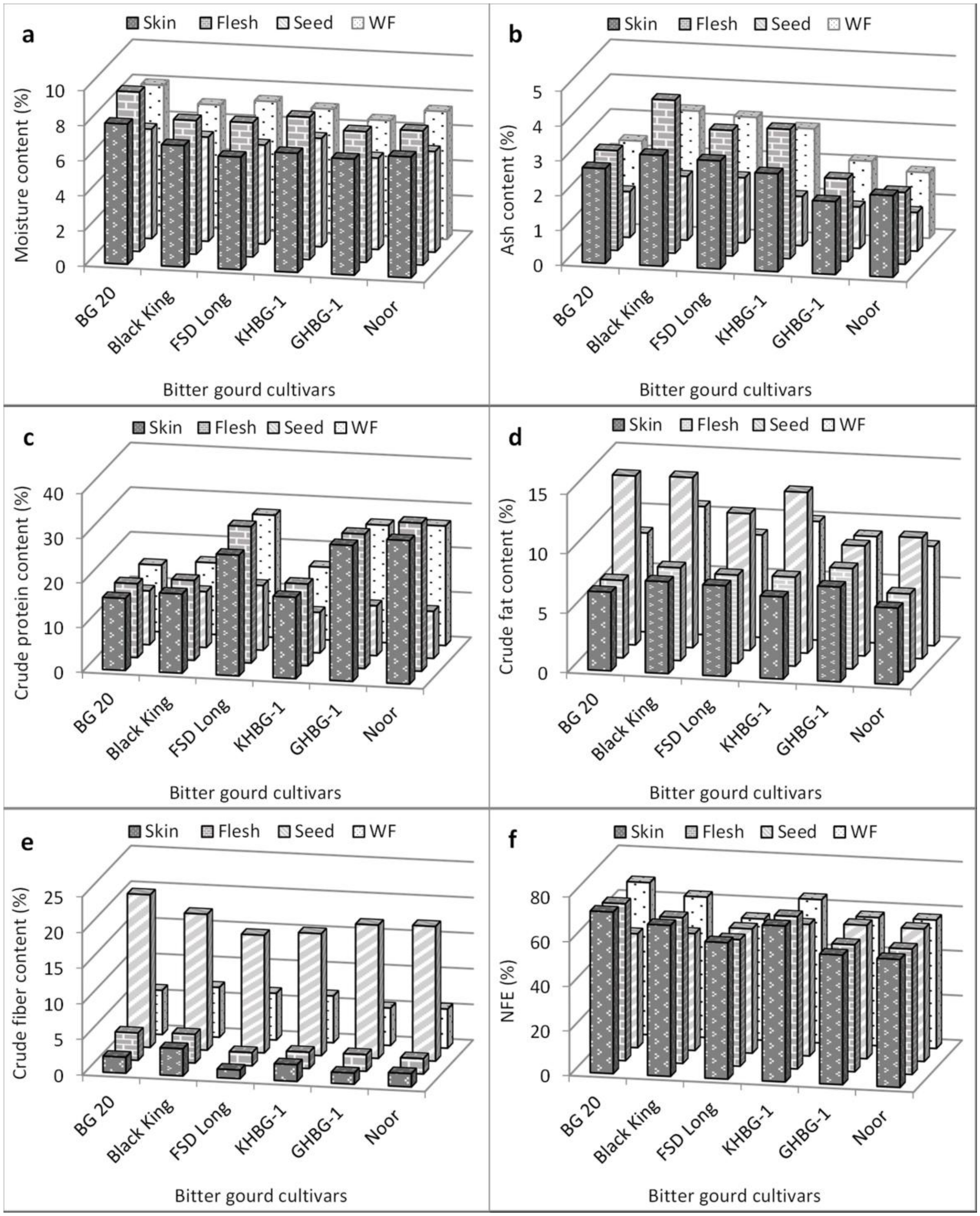

Fig. 3: Proximate analysis of parts of different cultivars bitter gourd: (a) moisture contents, (b) ash contents, (c) crude proteins, (d) crude fat contents, (e) crude fiber contents and (f) nitrogen free extract (NFE) contents.

and 4.09%, respectively. Bakare *et al*. (2010) reported higher moisture contents in seeds (20.69%) and low (10.74%) in fruit of bitter gourd. Low moisture contents (8.06%) were also detected by Hussain *et al*. (2009) in dried fruit samples of bitter gourd. Mathew *et al*. (2014) also found low moisture contents (7.00%) in bitter gourd seeds. Ali *et al*. (2008) studied three bitter gourd cultivars and revealed that the seeds of these cultivars had low moisture contents (7.62 to 8.20%). Contrary to these findings, Anjum *et al*. (2013) observed higher moisture contents in two bitter gourd cultivars *i.e*., 29.32 and 22.91%. Furthermore, very high moisture contents were observed by Ullah *et al*. (2011)

in four bitter gourd that ranged between 91.6 to 92.92%. Islam *et al*. (2011) also stated high moisture contents in flesh (92.4 to 93.5%) and seeds (53 to 75%). Very high values for moisture contents in certain experiments were due to use of fresh fruit samples for analysis.

The ash reflects the existence of minerals present in any plant part. In the present study, different cultivars showed considerable amount of ash contents in whole fruit and fruit parts. Hussain *et al.* (2024) found abundant ash contents in peel (6.26%), flesh (4.45%) and seeds (5.40%). Gayathri (2014) revealed that bitter gourd fruit possessed ash contents (2.76%). Contrary to this, Bangash *et al*. (2011) found 0.90% ash content in bitter gourd fruit. In a similar way, Ullah *et al*. (2011) revealed that bitter gourd had low ash content (0.75–1.20%). Contrary to these findings, Saeed *et al*. (2010) observed remarkably high ash contents in flakes, peel, and seeds with values of 6.43, 14.99 and 4.56%, respectively. They also illustrated variable amounts of ash in different components of bitter melon fruit. Similarly, Hussain *et al*. (2009) reported high ash contents (8.96±0.01) in fruits of vegetables. Mathew *et al.* (2014) investigated seeds of bitter gourd and found ample amount of ash (4.00%). Bakare *et al.* (2010) reported ash contents with values of 9.73 and 7.36% for seeds and fruit, respectively.

The results highlighted that protein contents were higher in bitter gourd in this study. Hussain *et al*. (2009) also reported 21.12% protein contents in bitter gourd fruit. A comparable protein contents in bitter gourd fruit (15.56%) was also reported by Aslam *et al*. (2013). Similarly, bitter gourd flakes and peel examined by Saeed *et al*. (2010) indicated 20.66 and 20.37% protein contents, respectively. They also reported that seeds of bitter gourd are valuable source of protein (19.01%). Similarly, high amount of protein (19.50%) was observed by Mathew *et al*. (2014). Anjum *et al*. (2013) examined that protein values showed significant differences due to selection of different bitter gourd cultivars. They observed 19.17 and 14.92% protein contents in the seeds of two different cultivars. Ullah *et al*. (2011) assessed low values (1.17–2.4%) for protein contents in the selected cultivars. Similarly, Hussain *et al.* (2024) found low protein contents (2.37–3.40%) in different parts of bitter gourd. Gayathri (2014) reported higher values (27.88%) for crude proteins in fruit. Many of these studies highlighted that protein contents were higher in flesh or edible portion while in some studies, protein contents were high in seeds (Islam *et al*. 2011). In different cultivars, protein contents differ widely, and it was observed that dark green varieties are low in protein contents than light green cultivars (Islam *et al*. 2011).

The present findings regarding crude fat contents are verified by study outcomes of Bakare *et al*. (2010) which depicted comparable crude fat contents of 6.11% in flesh and 11.50% in seeds. However, Saeed *et al.* (2010) observed low values of crude fat in flakes, seeds and peel with values of 0.25, 5.24 and 0.18%, respectively. Similarly, Hussain *et al.* (2024), reported that fat contents in bitter gourd peel, fruit and seeds were 1.03, 1.34 and 3.50%, respectively. On the other hand, Mathew *et al*. (2014) observed that seeds contained an abundant quantity of crude fat (34%). Aslam *et al*. (2013) reported high amount of fat (26.67%) in bitter gourd fruit. Different cultivars showed remarkable differences regarding lipid contents (Ali *et al*. 2008). These results were alike the findings of this study.

The fiber contents are valuable for gastrointestinal health besides other functions (Gill *et al*. 2021). The bitter gourd fruit is a valuable source of dietary fiber. Due to high fiber contents, bitter gourd has potential to lower the onset of number of maladies such as cancer, hypertension, diabetes, obesity gastrointestinal disorder and associated complications (Saldanha 1995). The present results indicated high fiber contents in the seeds than other parts. Saeed *et al*. (2010) revealed that crude fiber in seeds was higher (22.46%) followed by peel and flakes with values of 17.77 and 17.08%, respectively. Similarly, Mathew *et al*. (2014) determined 12% crude fiber in bitter melon seeds. Gayathri (2014) reported 2.31% crude fiber contents in bitter gourd fruit. Low fiber contents were observed in bitter melon (1.4%) by Bangash *et al*. (2011). Another research reported high fiber contents in seeds of two selected bitter gourd cultivars (Anjum *et al*. 2013).

The NFE primarily represents carbohydrates in plant materials. Different fruit parts and cultivars showed abundant quantity of NFE. The current results are also supported by Saeed *et al*. (2010) who observed high NFE in flakes (50.86%), peel (42.54%), and seed (44.64%). Gayathri (2014) also studied high carbohydrate contents (85.41 mg/100g) in fruit of bitter gourd. Aslam *et al*. (2013) also showed that bitter gourd has 43.20% carbohydrate content. Likewise, Hussain *et al*. (2009) found high amount of NFE (56.02%) in bitter gourd fruit. Slightly low values (32.51–35.52) for NFE have been reported in different bitter gourd cultivars (Ali *et al*. 2008). The reason behind these variations is genetic diversity in cultivars, impact of abiotic factors, stages of fruit maturity, agro-climatic conditions and post-harvesting conditions.

CONCLUSIONS

The different parameters related to proximate composition of flour of bitter gourd fruit showed that different cultivars and fruit parts showed remarkable differences regarding different nutritional components. The chemical composition is crucial in development of functional or designer foods. The results revealed that Black King cultivar proved the most promising followed by FSD Long and BG 20. It is recommended that these cultivars should be further analyzed for phytonutrient and biochemical evaluation.

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AUTHOR CONTRIBUTIONS

M, conceptualization and writing original draft; FS, overall supervision and data analysis; FN, visualization, review and editing.

CONFLICT OF INTEREST

The authors declared no conflict of interest

DATA AVAILABILITY

The data will be made available upon request to the author

ETHICS APPROVAL

Not applicable

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